Predictors of Work-Related Repetitive Strain Injuries in a Population Cohort

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Objectives. We assessed predictors of work-related repetitive strain injuries using data from 4 waves of the Canadian National Population Health Survey.

Methods. Participants were 2806 working adults who completed an abbreviated version of the Job Content Questionnaire in 1994–1995 and did not experience repetitive strain injuries prior to 2000–2001. Potential previous wave predictors of work-related repetitive strain injuries were modeled via multivariate logistic regression.

Results. Female gender (odds ratio [OR] = 1.98; 95% confidence interval [CI] = 1.24, 3.18), some college or university education (OR = 1.98; 95% CI = 1.06, 3.70), job insecurity (OR = 1.76; 95% CI = 1.07, 2.91), high physical exertion levels (OR = 2.00; 95% CI = 1.29, 3.12), and high levels of psychological demands (OR = 1.61; 95% CI = 1.02, 2.52) were all positively associated with work-related repetitive strain injuries, whereas working less than 30 hours per week exhibited a negative association with such injuries (OR = 0.2; 95% CI = 0.1, 0.7).

Conclusions. Modifiable job characteristics are important predictors of work-related repetitive strain injuries. (*Am J Public Health.* 2005;95:1233–1237. doi:10.2105/AJPH.2004.048777)

Repetitive strain injury (RSI) and cumulative trauma disorder (CTD) are 2 of several terms used to describe a group of activity-related soft-tissue injuries that include tendonitis, forearm myalgia, and nerve entrapment syndromes, among other conditions.[1] The area affected by RSI and CTD may be only the upper limbs, may include the neck and upper back,[2] or may encompass the lower back and lower limbs as well. RSIs and CTDs represent an important burden arising from both sport-[3] and work-related[4] activity, the latter generating considerable societal and employer costs through workers' compensation claims.[5]

Performing biomechanical/physical tasks, organization of work associated with tasks, and psychosocial stressors at work are among the causes of work-related RSI and CTD. These diverse causes have lead many work and health researchers to prefer the term work-related musculoskeletal disorders.[6–8] Other researchers have studied the work-related exposures that contribute to RSI and CTD. A systematic review[9] conducted in 1997 indicated a preponderance of cross-sectional studies focusing on work-related exposures among specific populations.[10] A few longitudinal general population studies in which exposures are assessed in advance of outcomes have been carried out.[11,12] In our study, inclusion of job characteristic questions in the first wave of a Canadian national longitudinal survey and questions about RSI in subsequent waves allowed us to analyze predictors of work-related RSI.

METHODS

Surveys

We used data from the Canadian National Population Health Survey (NPHS).[13] In this survey, a complex stratified, multistage sample design was used to randomly select approximately 20 000 households; people living on Indian reserves and military bases, along with those residing in institutions and in some remote areas, were excluded.[14] In 1994–1995, the household response rate was 88.7%. Within each household, 1 adult was asked detailed questions, and the response rate was 96.1% at this individual level (i.e., 17 626 individuals, each from a different household). Of the 1994–1995 participants, 17 276 (98.0%) were eligible for reinterviews in 1996–1997. Among those individuals, 93.6% responded in 1996–1997, 88.9% responded in 1998–1999, and 84.8% responded in 2000–2001.[15]

Population

We focused on respondents who, in 1994–1995, were aged 18 through 64 years, had paid employment (including those who were self-employed), and responded to an abbreviated set of items derived from the Job Content Questionnaire (JCQ).[16] Exclusions and listwise deletion of relevant missing variables resulted in an analysis sample of 2806.

Measures

Independent variables. We obtained sociodemographic data from the 1998–1999 wave of the NPHS (the wave closest in time to the 2000–2001 wave). Data included gender, age (consolidated into 4 groups), education (aggregated into 3 groups), and household income, categorized on the basis of respondents' household income after adjustment for household size according to low income cutoff criteria (Table 1).[17]

Comorbidity variables included chronic conditions and activity limitations. Respondents were asked whether they had long-term conditions (those having persisted or expected to persist 6 months or more) diagnosed by a health professional. Two of the possible responses were "arthritis" and "back problems excluding arthritis." We refer to the latter simply as "back problems." The questions on activity limitations tapped long-term physical or mental conditions, or health problems that limited the kind or amount of activity in which the respondent could engage, as well as long-term disabilities or handicaps. A derived variable was used to capture an affirmative response to any of these questions. To assess the contribution of such chronic conditions and activity limitations to RSIs reported in

TABLE 1—Reports of New Work-Related Repetitive Strain Injury (RSI) in 2000–2001, by Sociodemographic, Comorbidity, and Lifestyle Variables: Canadian National Population Health Survey

	No. of Participants[a]	New Work-Related RSI Reported, No. (%)	P[b]
Sociodemographic variables (1998–1999)			
Gender			.001
Female	1178	85 (7.2)	
Male	1628	70 (4.3)	
Age, y			.675
18–34	721	39 (5.4)	
35–44	1029	61 (5.9)	
45–54	754	43 (5.7)	
>54	302	12 (4.1)	
Marital status			.225
Married[c]	2035	106 (5.2)	
Other	771	49 (6.4)	
Household income			.066
Low	77	4 (5.5)	
Middle/high	2612	139 (5.3)	
Missing variable	117	12 (10.4)	
Education			.002
Secondary school or less	773	33 (4.3)	
Some college/university	778	62 (8.0)	
College/university	1255	60 (4.8)	
Comorbidity variables (1994–1995, 1996–1997, or 1998–1999)			
Back problem			.000
Yes	640	53 (8.3)	
No	2166	102 (4.7)	
Arthritis			.069
Yes	303	24 (7.8)	
No	2503	131 (5.3)	
Activity limitation			.002
Yes	503	42 (8.4)	
No	2303	113 (4.9)	
Lifestyle variables (1998–1999)			
Leisure time physical activity	.781		
Engage	2608	145 (5.57)	
Do not engage	198	10 (5.1)	
Daily smoker	.117		
Yes	644	44 (6.8)	
No	2162	112 (5.2)	

[a]Adjusted survey weights adding up to a sample size of 2806 were used.
[b]χ^2 test for difference in proportions.
[c]Includes common-law marriages.

2000–2001, we created a combined variable comprising any report of chronic condition or activity limitation across 3 previous waves (1994–1995, 1996–1997, 1998–1999).

Data on 2 lifestyle variables were available from the 1998–1999 wave: leisure time activity and smoking. Participation in leisure time physical activity was based on at least 1 positive response indicating that respondents had engaged in "physical activities not related to work" in the past 3 months. Smoking was dichotomized into daily smoking and less frequent/no smoking.

Respondents were asked whether they had worked for pay in the past 12 months; up to 6 jobs were recorded in each wave. Using the Canadian National Occupational Classification,[18] we grouped respondents' main jobs into the following categories: unskilled, semiskilled with secondary training, semiskilled with college or university training, and skilled/supervisor/semiprofessional/professional/management. Type of employment in 1998–1999 was dichotomized into full time (30 hours or more worked per week) and part time (less than 30 hours worked per week). Responses to the JCQ item focusing on job insecurity were dichotomized into high and low. A "high" level of insecurity was defined as respondents' agreement or strong agreement that they had an insecure job.

Job characteristic variables from the 1994–1995 wave, assessed via JCQ items, were rated on a 5-point Likert scale ("strongly agree" to "strongly disagree").[19] Physical exertion, measured via a single item, was dichotomized into high and low. A "high" level of exertion was defined as agreeing or strongly agreeing that one's level of physical exertion at work was high. Decision latitude or "control" was measured with a 5-item scale (learn new things, job requires high level of skill, freedom to decide how to do the job, work not repetitious, and a lot to say about what happens in the job). Psychological demands were measured with a 2-item scale (hectic work and conflicting demands). Social support at work was measured via a 3-item scale (supervisor helpful in getting work done, coworkers helpful in getting work done, people you work with not hostile). We dichotomized responses for psychological demands (top third of distribution vs other) as well as for decision latitude and social support (bottom third of distribution vs other).

Dependent variable. Data on RSIs were gathered via a question asking respondents whether they had experienced "injuries caused by overuse or repeating the same movement frequently in the previous year (for example, carpal tunnel syndrome, tennis elbow, or tendonitis) . . . which were serious enough to limit your normal activities." Those who responded "yes" were considered to have an RSI and then were asked about its cause ("Was this injury the result of doing

something [in various settings, including] at work?"). As our dichotomous dependent variable, work-related RSI was determined on the basis of participants' reports of incurring an RSI in 2000–2001 as a result of engaging in a task at work. To ensure incident rather than prevalent cases, we excluded those who reported RSIs attributed to any setting in 1996–1997 or 1998–1999.

Analysis

As recommended by Statistics Canada, adjusted survey weights were used in all analyses. Proportions of work-related RSI in 2000–2001 across previous wave variables were calculated and compared via a χ^2 test. Univariate logistic regression analyses were then conducted for each previous wave variable as a predictor of incident RSI in 2000–2001.

Because of the possibility of the NPHS multistage sample design resulting in correlated observations, the usual methods of regression would lead to underestimations of the standard errors of the estimated coefficients.[20] To allow for this sampling design effect, we used bootstrap weights provided by Statistics Canada.[21] All independent variables were entered into an initial multivariate logistic model. Variables that were not statistically significant at the .05 level ($P>.05$) were removed sequentially; their omission did not substantially alter (10% change)[22] the estimated coefficients for the main predictors of interest (work availability and job characteristic variables). Hosmer–Lemeshow and deviance goodness-of-fit statistics were used in assessing models.[23] All statistical analyses were performed with the SAS version 8.1 software package (SAS Institute Inc, Cary, NC).[24]

TABLE 2—Reports of New Work-Related Repetitive Strain Injury (RSI) in 2000–2001, by Occupation, Availability of Work Variables, and Job Characteristics From Previous Waves: Canadian National Population Health Survey

	No. of Participants[a]	New Work-Related RSI in 2000–2001, No.[a] (Row %)	P[b]
Occupation (1998–1999)			.365
Management, skilled/university	744	35 (4.7)	
Semiskilled/secondary, postsecondary	1799	108 (6.0)	
Unskilled	263	12 (4.9)	
Work availability variables			
Employment status (1998–1999)			.024
Full time	2504	147 (5.9)	
Part time	302	8 (2.7)	
Job insecurity (1994–1995)			.000
High	560	49 (8.7)	
Low	2246	106 (4.7)	
Job characteristics (1994–1995)			
Decision latitude			.084
High	1868	93 (5.0)	
Low	938	62 (6.6)	
Psychological demands			.001
High	1035	78 (7.5)	
Low	1771	78 (4.4)	
Social support at work			.155
High	1744	88 (5.1)	
Low	1062	67 (6.3)	
Physical exertion			.000
High	1194	90 (7.6)	
Low	1612	65 (4.0)	

[a]Adjusted survey weights adding up to a sample size of 2806 participants were used.
[b]χ^2 test of presence of RSI by row categories for each variable.

RESULTS

Overall, 155 of the cohort participants (5.5%) reported a new work-related RSI in 2000–2001. Significantly different percentages of women and men experienced such injuries (7.2% vs 4.3%: $P=.0011$). The primary parts of the body affected were (1) wrist or hand (n=57; 36.8%), (2) shoulder or upper arm (n=31; 20.0%), (3) elbow or lower arm (n=23; 14.8%), (4) lower back (n=17; 11.0%), (5) upper back (n=7; 4.5 %), (6) knee or lower leg (n=10; 6.6%), and (7) neck or other (n=10; 6.5%). Interestingly, participants with some college or university education were more likely than participants in other education groups to experience an RSI (Table 1). Although comorbidity was infrequent, reports of new work-related RSIs in 2000–2001 were more prevalent among those with an activity limitation and those with a back problem reported in previous waves.

A smaller proportion of part-time workers (less than 30 hours per week) than full-time workers reported a work-related RSI (Table 2). High levels of job insecurity, psychological demands, and physical exertion were all associated with greater proportions of subsequent work-related RSIs.

In multivariate analyses, the demographic variables gender and educational level remained significant predictors (Table 3). Lifestyle variables remained unimportant in terms of subsequent work-related RSI. Both work availability variables remained predictors, with high job insecurity elevating risk of experiencing an RSI (odds ratio [OR]=1.76; 95% confidence interval [CI] = 1.07, 2.91) and part-time work decreasing risk (OR=0.33; 95% CI= 0.13, 0.88). Finally, high levels of both psychological demands (OR=1.61; 95% CI=1.02, 2.52) and physical exertion (OR=2.00; 95% CI=1.29, 3.12) remained important predictors of development of future work-related RSI.

DISCUSSION

Our analyses show that sociodemographic, work availability, and job factors predict new occurrences of work-related RSIs in a popula-

TABLE 3—Predictive Factors for Occurrence of New Work-Related RSI in 2000–2001 in Final Multivariate Logistic Regression Model: Canadian National Population Health Survey

	Estimated Odds Ratio (95% Confidence Interval)
Female vs male (reference)	1.98 (1.24, 3.18)[a]
Married[b] vs other (reference)	0.80 (0.48, 1.34)
Age, y	
18–34 (reference)	1.00
35–44	1.24 (0.68, 2.26)
45–54	1.28 (0.66, 2.48)
>54	1.10 (0.49, 2.48)
Education	
Secondary school or less (reference)	1.00
Some college/university	1.98 (1.06, 3.70)[a]
College/university	1.21 (0.66, 2.24)
Back problem[c] vs none (reference)	1.53 (0.92, 2.55)
Activity limitation vs none (reference)	1.58 (0.88, 2.55)
Leisure time physical activity, yes vs no (reference)	0.88 (0.30, 2.58)
Daily smoker, yes vs no (reference)	1.20 (0.69, 2.09)
Occupation	
Unskilled	0.94 (0.40, 2.19)
Semiskilled	1.25 (0.75, 2.07)
Professional/semiprofessional/skilled/supervisor (reference)	1.00
Part time vs full time (reference)	0.33 (0.13, 0.88)[a]
High job insecurity vs low (reference)	1.76 (1.07, 2.91)[a]
High psychological demands vs low (reference)	1.61 (1.02, 2.52)[a]
High physical exertion vs low (reference)	2.00 (1.29, 3.12)[a]

Note. Hosmer–Lemeshow goodness-of-fit $\chi^2 = 10.4$, $df = 8$, $P = .2355$; deviance $\chi^2 = 870$, $df = 1667$, $P = 1.000$.
[a]Confidence interval does not include 1.
[b]Includes common-law marriages.
[c]Refers to nonarthritic back pain.

tion cohort involving broad coverage of occupations and an excellent response rate.[19] These findings extend those of cross-sectional analyses of the NPHS population[25] and that of its successor, the Canadian Community Health Survey.[26] Also, they are consistent with similar research showing the importance of job-related physical risk factors,[6,9] job psychosocial factors,[7,27] and their combination[11,12,28] in regard to work-related RSIs, CTDs, and work-related musculoskeletal disorders among working populations. The protective nature of part-time (relative to full-time) employment is most likely attributable to decreased exposures to such risk factors and greater time for rest of the affected body areas.

Women were more likely than men to develop a new work-related RSI. Women's jobs, particularly in micro-assembly and office work, have been characterized as involving a high risk for CTD or work-related RSI, even though recognition of workers' compensation claims has been proportionately higher among men in some jurisdictions.[29] Interestingly, participants with some formal college or university education were more likely than those in other education groups to report experiencing work-related RSIs. Such individuals may be more aware of the relationship between work, demanding conditions, and having an RSI, and therefore may be more likely to attribute their RSI to a work-related activity. Alternatively, they may be more concerned than individuals in other education groups that their current jobs do not match their job expectations, as observed in the Ontario Universities Back Pain Study, in which individuals who perceived their level of education as high relative to others employed in the same work were more likely to report back pain.[30]

Our finding in the bivariate analyses—that those reporting back problems or activity limitations in previous waves had a greater risk of developing new work-related RSIs in 2000–2001—extends the finding that a previous back injury is an important risk factor for sustaining a subsequent back injury[8] to the broader outcome of work-related RSI. Cohort analyses examining extension and recurrence of musculoskeletal injuries in working populations[31] must control for previous injury history.

Limitations

Unfortunately, the NPHS data set did not include questions on RSI in 1994–1995 or questions on job characteristics after 1994–1995, and thus we were not able to explicitly model ongoing exposure–symptom relationships across waves. Furthermore, self-reports of RSIs occurring at work may either overrepresent or underrepresent "work-related conditions" categorized according to the World Health Organization definition,[32] which encompasses both work-caused and work-aggravated conditions. Because RSIs involve a sufficient number of causal factors, as exemplified by the significant predictors in our study, specific attribution is exceedingly difficult even with additional work and clinical information.[1] In addition, the NPHS involved the use of an abbreviated set of JCQ items, impairing traditional measurement properties.[25] However, accounting for the heterogeneous nature of the items, particularly those making up the decision latitude and psychological demands scales, we would argue that the scale variables should be considered composites, in which case traditional psychometric performance applied to latent variables is less crucial.[33]

Implications for Prevention

Our findings add to the existing empirical evidence of the role of both physical and psychosocial work factors in the onset of RSI, CTD, and work-related musculoskeletal disorders.[34] Such evidence should lead workplaces and governments to consider the wide range of preventive measures documented by re-

searchers into and practitioners of ergonomics.[35] Manuals have already been prepared to guide workplaces in the implementation of ergonomic programs that can reduce the physical demands of work.[36]

Similarly, there is considerable evidence from the organizational behavior and industrial psychology literature that work reorganization can reduce psychological demands.[37] Yet, even among those with RSIs or CTDs, secondary prevention activities designed to correct risky conditions may be very restricted in terms of coverage.[38] Etiological research findings, such as those presented here, must be complemented with rigorous evidence on the effectiveness of workplace and regulatory interventions to persuade company and union officials and government policymakers to reduce the burden of work-related RSI, CTD, and work-related musculoskeletal disorders. ■

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Contributors

All of the authors interpreted the findings and reviewed multiple drafts of the article. D.C. Cole led the writing, with the participation of S. Ibrahim and H.S. Shannon.

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Human Participant Protection

We used the NPHS data sets with previous approval of Statistics Canada for the proposed analyses, in keeping with Canadian federally mandated health research requirements for such data. NPHS participants consented to share their survey responses with third-party researchers through Statistics Canada.

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